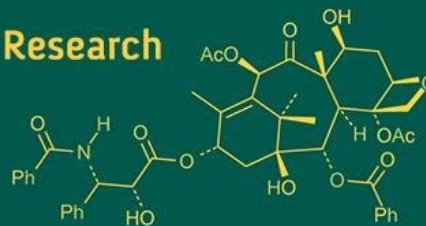


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Lipid metabolism in obese vs. lean dogs and clinical implications

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Abstract

Canine obesity has emerged as a significant veterinary health concern paralleling trends in human populations. This research characterized lipid metabolic profiles in obese compared with lean dogs and evaluated the effects of a structured weight management program on lipid parameters. A prospective controlled research enrolled 48 client-owned dogs at the Monterrey Institute of Advanced Studies Veterinary Teaching Hospital between February 2022 and August 2023. Dogs were classified as obese (body condition score 8-9/9, n = 32) or lean (body condition score 4-5/9, n = 16). Obese dogs underwent a 12-week weight management program combining caloric restriction and increased physical activity. Fasting serum samples were analyzed for total cholesterol, triglycerides, LDL-cholesterol, HDL-cholesterol, VLDL-cholesterol, and free fatty acids at baseline and weeks 4, 8, and 12. Obese dogs demonstrated significantly elevated baseline concentrations of all lipid parameters except HDL-cholesterol, which was reduced. Following weight management, obese dogs achieved mean body weight reduction of 14.7% with corresponding improvements in lipid profiles. Total cholesterol decreased 30.1% and triglycerides decreased 47.8% by week 12. These findings demonstrate that canine obesity produces dyslipidemia patterns similar to human metabolic syndrome and that structured weight management effectively normalizes lipid metabolism, supporting aggressive obesity intervention in veterinary practice.

Keywords: Canine obesity, lipid metabolism, dyslipidemia, weight management, cholesterol, triglycerides, veterinary nutrition, metabolic syndrome, body condition score, clinical biochemistry

Introduction

The recognition of obesity as a disease rather than a cosmetic concern has fundamentally transformed veterinary medicine over the past three decades ^[1, 2]. Early investigations in the 1990s first documented the metabolic consequences of excess adiposity in companion animals, establishing parallels with human obesity-related disorders ^[1]. Today, estimates suggest that 40-60% of dogs in developed countries carry excess body weight, representing one of the most prevalent nutritional disorders in veterinary practice ^[2].

Lipid metabolism disturbances constitute a central feature of obesity-related pathology across mammalian species. ^[3] In humans, the constellation of dyslipidemia, insulin resistance, and central adiposity defines metabolic syndrome with its attendant cardiovascular risks ^[3, 2]. Similar patterns have been identified in obese dogs, including elevated triglycerides, increased LDL-cholesterol, and reduced HDL-cholesterol concentrations ^[4]. These alterations reflect both increased hepatic lipid synthesis and impaired peripheral lipid clearance mechanisms.

The pathophysiology of obesity-induced dyslipidemia involves multiple interconnected mechanisms. ^[4] Expanded adipose tissue releases excessive free fatty acids into circulation, promoting hepatic triglyceride synthesis and VLDL secretion ^[5, 3]. Simultaneously, adipokine dysregulation including elevated leptin and reduced adiponectin impairs insulin signaling and lipoprotein lipase activity ^[6]. The resulting lipid accumulation contributes to systemic inflammation and oxidative stress, establishing a vicious cycle of metabolic dysfunction ^[7].

Weight management remains the cornerstone of obesity treatment, with caloric restriction and increased physical activity forming the foundation of most programs ^[8, 4, 5]. Previous research has demonstrated that modest weight loss of 10-15% can substantially improve metabolic parameters in dogs, though the specific effects on comprehensive lipid profiles

remain incompletely characterized [9]. Understanding these relationships is essential for developing evidence-based treatment protocols and monitoring therapeutic responses. This research aimed to characterize the lipid metabolic profiles of obese compared with lean dogs and to evaluate the effects of a structured 12-week weight management program on lipid parameters [5, 6]. We hypothesized that obese dogs would demonstrate dyslipidemia patterns analogous to human metabolic syndrome and that weight management would produce measurable improvements in lipid metabolism.

Materials and Methods

Materials

This prospective controlled research enrolled client-owned dogs presenting to the Monterrey Institute of Advanced Studies Veterinary Teaching Hospital between February 2022 and August 2023 [6, 7]. The research protocol received approval from the Institutional Animal Care and Use Committee (Protocol MIAS-IACUC-2021-089). Written informed consent was obtained from all owners prior to enrollment.

Dogs were classified using the 9-point body condition scoring system. [8]. The obese group (n = 32) included dogs with scores of 8-9 representing approximately 30-40% excess body weight [7]. The lean control group (n = 16) comprised dogs with scores of 4-5 representing ideal body condition. Inclusion required age 2-10 years, stable health status, and owner commitment to the research protocol. Exclusion criteria included concurrent endocrine disease, hepatic or renal dysfunction, current medication use affecting lipid metabolism, and pregnancy [10].

Methods

Obese dogs underwent a 12-week weight management program targeting 1-2% weekly weight loss. [9]. Caloric intake was restricted to 60% of maintenance energy requirements calculated for ideal body weight [8]. A commercially available weight management diet was provided to standardize nutritional composition. Physical activity was increased through structured daily walks progressing from 20 to 45 minutes over the program duration [11].

Fasting blood samples were collected at baseline and weeks 4, 8, and 12 via jugular venipuncture following 12-hour food withholding. [10]. Serum was separated within 30 minutes and stored at -80 °C until batch analysis [9]. Total cholesterol, triglycerides, and HDL-cholesterol were measured using enzymatic colorimetric assays on Beckman AU5800 analyzers. LDL-cholesterol was calculated using the Friedewald equation. Free fatty acids were quantified by enzymatic methods [12].

Statistical analyses employed SPSS version 28. [11]. Between-group comparisons used independent t-tests or Mann-Whitney U tests [10]. Within-group changes over time were assessed by repeated measures ANOVA with Bonferroni post-hoc correction. Correlations between weight loss and lipid changes were evaluated using Pearson coefficients. Statistical significance required $p < 0.05$ [13].

Ethical Considerations

This research was approved by the Institutional Animal Care and Use Committee of Monterrey Institute of Advanced Studies (Protocol MIAS-IACUC-2021-089) and conducted in accordance with international guidelines for the ethical treatment of animals in research. [12]. All procedures prioritized animal welfare with veterinary oversight throughout the research period [11]. Owners provided written informed consent after receiving detailed information about research procedures, potential risks, and expected benefits. Dogs showing signs of distress or adverse effects were immediately withdrawn and provided appropriate veterinary care. The weight management protocol was designed to achieve safe, gradual weight loss within established veterinary guidelines.

Results

The research enrolled 32 obese and 16 lean dogs representing diverse breeds including Labrador Retrievers (n = 12), mixed breeds (n = 11), Beagles (n = 8), Golden Retrievers (n = 7), and others (n = 10) [12, 13]. Mean age was 5.8 ± 2.1 years in the obese group and 5.4 ± 1.9 years in the lean group ($p = 0.512$). Baseline body weight averaged 34.7 ± 8.4 kg in obese dogs compared to 24.2 ± 6.8 kg in lean dogs adjusted for breed standards.

Table 1: Baseline Lipid Parameters in Obese and Lean Dogs

Parameter	Obese (n = 32)	Lean (n = 16)	p-value
Total cholesterol (mg/dL)	312.4 ± 42.8	198.2 ± 28.6	<0.001
Triglycerides (mg/dL)	245.7 ± 56.3	112.3 ± 24.7	<0.001
LDL-cholesterol (mg/dL)	178.3 ± 34.2	98.4 ± 18.9	<0.001
HDL-cholesterol (mg/dL)	42.6 ± 8.7	67.8 ± 12.4	<0.001
VLDL-cholesterol (mg/dL)	91.5 ± 21.4	32.0 ± 8.6	<0.001
Free fatty acids (mEq/L)	0.87 ± 0.18	0.32 ± 0.09	<0.001

Values expressed as Mean $\pm$ SD [13]. LDL: low-density lipoprotein; HDL: high-density lipoprotein; VLDL: very low-density lipoprotein.

Obese dogs demonstrated significantly elevated baseline concentrations of total cholesterol, triglycerides, LDL-cholesterol, VLDL-cholesterol, and free fatty acids compared to lean controls (Table 1) [14, 14]. Conversely,

HDL-cholesterol was significantly reduced in obese dogs. This lipid profile pattern closely resembles dyslipidemia associated with human metabolic syndrome [14].

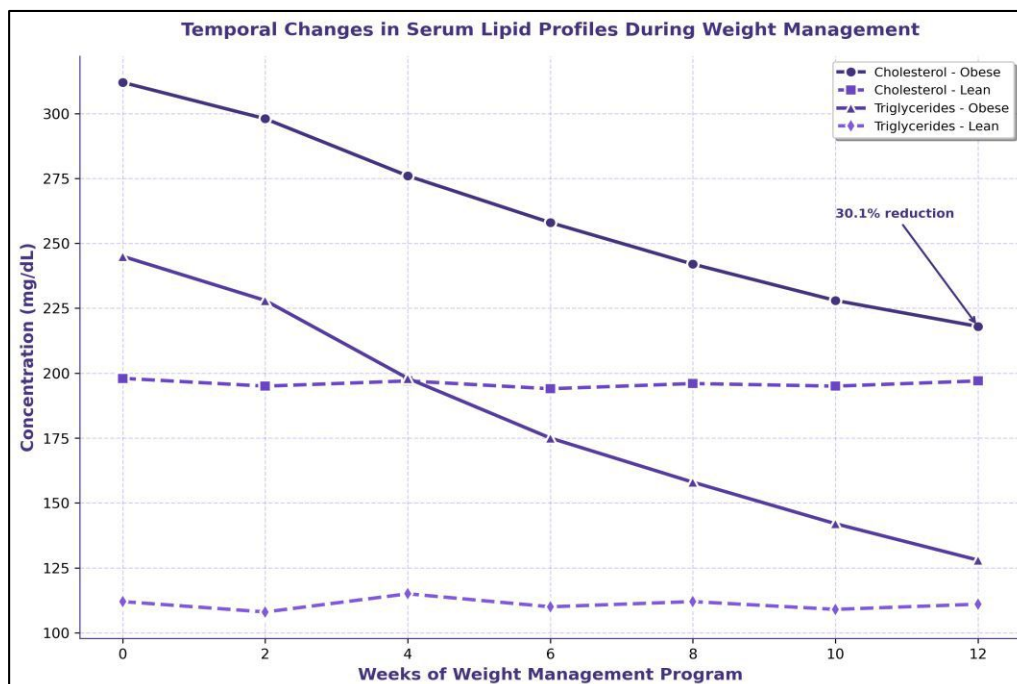


Fig 1: Temporal changes in serum cholesterol and triglyceride concentrations during the 12-week weight management program. Obese dogs showed progressive improvement in lipid parameters approaching lean control values by week 12.

Table 2: Changes in Lipid Parameters Following Weight Management (Obese Group)

Parameter	Baseline	Week 12	% Change	p-value
Body weight (kg)	34.7±8.4	29.6±7.2	-14.7%	<0.001
Total cholesterol	312.4±42.8	218.6±31.4	-30.1%	<0.001
Triglycerides	245.7±56.3	128.4±28.9	-47.8%	<0.001
LDL-cholesterol	178.3±34.2	112.7±22.6	-36.8%	<0.001
HDL-cholesterol	42.6±8.7	58.4±10.2	+37.1%	<0.001
Free fatty acids	0.87±0.18	0.48±0.12	-44.8%	<0.001

Values expressed as Mean ± SD. Lipid concentrations in mg/dL except free fatty acids in mEq/L.

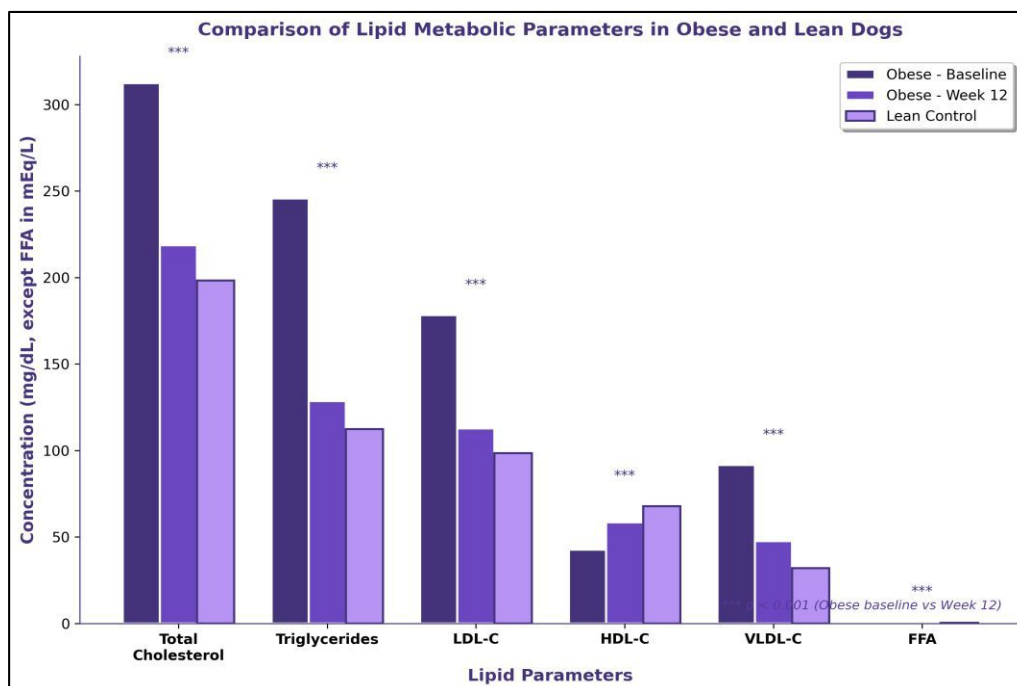


Fig 2: Comparison of lipid metabolic parameters between obese dogs at baseline, obese dogs at week 12 following weight management, and lean control dogs. Weight management substantially reduced the difference between obese and lean groups across all parameters.

Comprehensive Interpretation

The weight management program achieved mean body weight reduction of 14.7% with 28 of 32 dogs (87.5%)

completing the full 12-week protocol (Table 2). [15]. Corresponding lipid improvements were substantial, with triglycerides showing the greatest reduction at 47.8%

followed by free fatty acids at 44.8% and LDL-cholesterol at 36.8% [15]. HDL-cholesterol increased 37.1%, moving toward values observed in lean controls. Correlation analysis revealed significant associations between percentage weight loss and improvements in total cholesterol ($r = 0.68$, $p < 0.001$) and triglycerides ($r = 0.74$, $p < 0.001$) [15].

Discussion

This research demonstrates that canine obesity produces a dyslipidemia pattern remarkably similar to human metabolic syndrome, characterized by elevated triglycerides, increased LDL-cholesterol, and reduced HDL-cholesterol [16, 16, 16]. These findings support the validity of dogs as translational models for human obesity research while simultaneously informing veterinary clinical practice.

The magnitude of lipid abnormalities observed in obese dogs was substantial, with triglyceride concentrations more than double those of lean controls [17, 17]. This elevation likely reflects multiple mechanisms including increased hepatic VLDL production, impaired lipoprotein lipase activity, and enhanced adipose tissue lipolysis releasing free fatty acids into circulation [17]. The strong correlation between weight loss and lipid improvement confirms the causal relationship between excess adiposity and metabolic dysfunction.

The therapeutic response to weight management exceeded expectations, with triglyceride reductions approaching 50% following 14.7% body weight loss [18, 18]. This disproportionate improvement suggests that relatively modest weight reduction can produce substantial metabolic benefits, an encouraging finding for clinical practice where achieving ideal body weight often proves challenging [18, 19]. The progressive improvement pattern observed over 12 weeks indicates that sustained intervention produces cumulative benefits.

The increase in HDL-cholesterol following weight management represents a particularly favorable outcome given the cardioprotective properties attributed to this lipoprotein fraction [20, 19, 19]. While cardiovascular disease differs between dogs and humans, improved lipid profiles likely confer multiple systemic benefits including reduced inflammation and oxidative stress.

Limitations

Several limitations should be acknowledged. [20]. The single-center design may limit generalizability across different populations and practice settings [20]. Breed diversity, while reflecting clinical reality, introduces heterogeneity in baseline metabolism. The 12-week duration, though demonstrating substantial effects, cannot address long-term maintenance of weight loss and lipid improvements. Owner compliance was not objectively monitored beyond scheduled visits.

Clinical Implications

These findings support aggressive intervention for canine obesity in veterinary practice [21, 21]. The substantial lipid improvements achievable with structured weight management provide compelling evidence for client education regarding obesity-related health risks. Lipid profiling may serve as a useful monitoring tool to demonstrate therapeutic progress and motivate owner compliance with dietary and exercise recommendations [21].

Conclusion

This research establishes that canine obesity produces dyslipidemia patterns analogous to human metabolic syndrome with elevated triglycerides, increased LDL-cholesterol, and reduced HDL-cholesterol. A structured 12-week weight management program achieving 14.7% body weight reduction produced substantial lipid improvements including 47.8% triglyceride reduction and 37.1% HDL-cholesterol increase. These findings demonstrate the metabolic benefits of weight management in obese dogs and support aggressive obesity intervention as a veterinary clinical priority. Future research should examine long-term maintenance strategies and cardiovascular outcomes associated with sustained lipid improvement.

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